

# MATHEMATICS TEXTS: WORKSHEETS AND GENRE-BENDING

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*This paper reports an in-depth study that explores the nature and use of mathematics worksheets using a genre analysis approach. Nine secondary level teachers with collective experience from five different countries participated. Through individual online and focus group interviews teachers shared their own worksheets and their understandings and use of worksheets for teaching and learning math. Results indicate that mathematics worksheets have culturally recognizable features and characteristics, they are used to emphasize procedural over conceptual aspects of mathematics learning, and can structure the way mathematics is taught. This study highlights the potential of genre-bending as an approach to extend and re-imagine the structure and use of mathematical texts such as worksheets.*

## INTRODUCTION

In many countries around the world teaching and learning mathematics involves the use of curriculum materials such as mathematics textbooks (Schmidt et al., 1997). In addition to the textbook, or sometimes in place of it, mathematics worksheets distributed by teachers to their students also play a role in mathematics education. As with other curriculum materials mathematics worksheets can impact the ways teachers teach and interact with their students as well as influence their own and students' interaction with mathematics (Mousley, 2012). Problems selected by teachers and posed to students can communicate implicit understandings of what it means to do mathematics and what is involved in getting better at it (Schoenfeld, 1992). Understanding better the kinds of mathematics problems teachers select or design and offer their students can provide insight into how materials are used, what is taught and learned, and how teacher education can better support learning to teach (Nicol & Bragg, 2009). Although there is increasing research on the nature and use of mathematics textbooks (Haggarty & Pepin, 2002), we know little about the nature and use of mathematics worksheets including their textual features and how they are used to teach mathematics (Kaymakci, 2012).

In this paper we explore the textual and contextual features of mathematics worksheets. We use genre analysis (Gerofsky, 2012; Kearsy, 1997) as a dynamic and holistic method to examine how worksheets, as text, are shaped and used, and thereby how they might provide opportunities to be imagined differently. With this paper our purpose is twofold: 1) to provide insight into the nature and use of mathematics worksheets through a small empirical study; and 2) explore the potential of genre analysis as an approach to understand the use and impact of curriculum materials such as mathematics worksheets.

## THEORETICAL CONSIDERATIONS

Studies on the analysis of curriculum materials reveal their impact and role in mathematics teaching and learning. They explore what texts are (e.g. Love & Pimm, 1996), how they are accessible to students (e.g. Van Dormolen, 1986), how teachers and students conceptualize and use texts (e.g. Remillard, 2000), and how the power of texts can become a “surrogate curriculum” (O’Keeffe, 2013). International studies of textbooks such as the Third International Mathematics and Science Study [TIMSS] found that student achievement is impacted by curricular and pedagogical intentions presented in textbooks (Schmidt et al., 1997) and that textbooks are “important mediators between policy and pedagogy” (Valverde et al., 2002, p. 171). These studies typically analysed textbooks for their structural features and organizational characteristics through examination of the intended, implemented and attained curriculum.

More recent studies employ a linguistic approach to analyse mathematics curriculum materials in order to better understand how mathematics activities are presented and the kinds of mathematical messages portrayed. Drawing from a systemic functional linguistic approach Morgan (1996) proposes a method to examine mathematical texts through the analysis of language and considers “the ways in which reasoning is expressed” (p. 7). Herbal-Eisenmann and Wagner (2007) build on Morgan’s work and examine the use of imperatives, pronouns and modality in mathematics textbooks and found how language choices within a text not only influences how readers make sense of it but also how the text might position students in relation to other students and their teachers.

Although mathematics worksheets are used at the elementary and secondary school levels there are few studies that focus explicitly on worksheets. An exception is Mousley (2003) who examined how a particular worksheet on the topic of percentages was used by two Grade 6 teachers and found that the worksheet shaped how the teacher and students interacted with each other. However, we know little about the nature of mathematics worksheets, how they are conceptualized, their language, and how they are used. Genre analysis provides an approach to understand both the features of text and the relationship between the participants (producers, consumers, and content itself) in that text (Kearsey, 1997). Whereas most previous studies of curriculum materials in mathematics education focus on either the features of or the use of the materials, genre analysis brings the study of these two areas together for a more holistic approach to text analysis.

Genre analysis conceptualizes genre as “a culturally-recognizable form” and involves asking questions about the presence and nature of the particular generic form, such as mathematics worksheets, from many different disciplinary perspectives. Genre can be defined as a category, a kind, or a type of artistic, musical, or literary composition that is characterized by a certain style, form, or content. More recently genre is considered to be a “form of cultural knowledge that conceptually frame[s] and mediate[s] how we understand and typically act within various situations” (Bawarshi & Reiff, 2010, p. 3).

From this view, a genre analysis of a worksheet not only provides insights regarding the features of the text, but also the producers' intentions, how the readers are addressed, and the kind of motives portrayed by the genre itself. Genre analysis can help to answer the question of what a worksheet is. It is also an approach that can provide opportunities to consider or re-imagine what a worksheet could be; to explore what Gerofsky (2012) refers to as the genre-benders of mathematics texts. Thus the focus of our study is on mathematics worksheets: What kind of genre are mathematics worksheets? How do teachers report on their use? And in what other ways might worksheets be imagined?

## **DATA COLLECTION AND ANALYSIS**

This report draws upon an in-depth study that included both conceptual and empirical data phases. The conceptual phase involved examining worksheets as a cultural and pedagogic genre. The empirical phase worked with 8 experienced and 1 novice secondary school level educators who, at the time of this study, were also graduate students at a major university (8 participants) or retired (1 participant). Four participants earned their undergraduate degrees from Canada, two from China, one from Belize, one from India, and one from the United States of America (US). Participants were asked to provide samples of mathematics worksheets from their own teaching resources and participated in two individual on-line interviews along with a 1 hour focus group interview.

The first individual interview focused on gathering participant background information and how participants say they used worksheets in their teaching. This was followed by a focus group interview in which participants shared their experiences and understandings of mathematics worksheets. In order to better understand what counted as a worksheet and what didn't participants were provided with a range of worksheets and asked to examine them for their features, similarities and differences. They were also asked to provide samples of worksheets they had used from their own teaching resources and examples they thought could lie on the boundary of counting as a worksheet. When needed participants translated their worksheets to English. The focus group was followed by a second individual interview to further pursue comments and ideas shared during the group interview. Questions asked during the interviews included: What are your memories of worksheets as a student? How would you describe what a worksheet is and what it is used for? In what situations would you use mathematics worksheets? Are worksheets for all students? What did using worksheets accomplish for you? How do they differ from mathematics textbooks? All interviews were audio recorded. Data therefore included copies of participant's mathematics worksheets (22 worksheets; 295 questions in total), online interview text, and transcriptions of the audio-recorded interviews.

Data analysis drew upon genre analysis approaches that included a study of the existence of worksheets, their historical development, and their defining features and characteristics. Language analysis included coding worksheets at a word level by

identifying imperatives, pronouns and modality (Herbel-Eisenmann & Wagner, 2007) and in terms of the placement of mathematics in the worksheets (Morgan, 1996). Analysis focused not only on the features of worksheets but also on the contexts in which they were used as well as the stated relationships by teachers on the interactions between the teacher, student and the mathematics.

## RESULTS

Our findings are presented in two parts: 1) a focus on the existence, features and characteristics of mathematics worksheets; and 2) a focus on their use and purpose. For this paper we briefly highlight results on worksheet features and characteristics (part 1) in order to provide more depth on their use (part 2).

### Existence, features, and language of mathematics worksheets

The conceptual phase included a general search to verify the cultural recognition of mathematics worksheets as a genre. Entering “mathematics worksheets” as a key phrase in the Google search engine revealed a result of 4,410,000 documents (May 14 2013). A search was conducted in other languages as well: Turkish “matematik calisma kagitlari” revealed 445,000 documents; German “mathematic arbeitsblatt” revealed 823,000 documents, and Chinese “数学随堂小试卷” revealed 2,110,000. This abundance of documents provides evidence that internationally mathematics worksheets are a culturally recognizable form.

Analysis of participants’ submitted mathematics worksheets found common features among the worksheets on form, content, graphics and language as shown in Table 1.

Features	Detailed Characteristics
Form	Page full of a series of math questions; organized into columns and rows; includes a math topic as title; requires completion by students
Content	Developed by teachers; required by students to complete; questions listed from easy to more difficult; focuses on one particular math topic; emphasizes certain skills
Graphics	No or few graphics; few words; no or few variations of representation such as graphs, numerical, illustrations
Linguistic	Use of symbolic statements; use of imperatives (e.g. find, calculate, divide); use of sentence phrases (e.g. fill in the blanks)

Table 1: Common features of teachers’ mathematics worksheets

Participants self-identified their mathematics worksheets as central to, peripheral to and contrasting with what might commonly be referred to as mathematics worksheets, or in other words with the genre of mathematics worksheets. According to participants, worksheets that are central to the genre provide repetitive practice questions for mathematical fluency and accuracy. Participants identified worksheets that were peripheral as focusing on skill practice but also including different activities such as

sketching, using a number line, or communicating mathematical reasoning or including questions that were more open-ended or personalized to student interests. All participants agreed that worksheets that could be considered as on the boundary of counting as a worksheet were less focused on drilled practice and included more use of graphics (pictures or graphs), complex language structures, and required more critical reasoning.

A language analysis of participants' worksheets focused on the frequency of pronouns, imperatives, and modality of the text indicated that the use of imperatives was the most frequent occurring linguist form in the data set. There were 139 imperative statements within the worksheets. Of these 17 were categorized as inclusive imperatives (e.g., show, explain, describe) while 121 were exclusive imperatives (e.g., find, calculate, express, determine, write) [I'm not sure of the difference between inclusive and exclusive – can you add something to this?]. There were 25 pronouns found across all the samples: 2 first person plural pronouns (we), 17 second person pronouns, and 8 third person pronouns. No first person singular pronouns were found. Modality, an aspect of text that reveals how human agency is constructed within the text, was also analyzed. Modality examined through the use of modal auxiliary verbs such as must, will, could, or might revealed that 11 of the 22 worksheet samples used modal verbs. In total 22 modal verbs were found across all the samples with the verb “can” being the most frequent (11 times).

### **How teachers describe, use, critique and imagine worksheets**

Analysis of individual and focus group interviews reveals that all participants distinguished worksheets as being quite different from class handouts. For example, worksheets were for “practice, practice, practice” (Anton) or “a series of questions with single right answers” (Rambo). Four of the nine participants associated worksheets with acquiring fluency and accuracy while handouts were used to engage students in critical thinking or conceptual understanding. In this way participating teachers stated they found worksheets limiting, with a focus on repetitive, drill type questions, worksheets tended to lack challenging questions or prompt critical thinking. Mohna's comment reflected others: “teachers don't use [worksheets] as a tool for critical thinking or conceptual thinking” worksheets generally focus on “what you've already learned.”

Although participants' descriptions of worksheets were similar, their pedagogical use of worksheets varied. Some said that they used worksheets as preparation for tests (Lizzy), homework and practice to sharpen students' memory (Anton), for practice following a lesson (Chloe), to develop students' independent studying habits (Serena), to provide time for teachers to circulate around the class and provide individual help to students (Pascal), or for evaluation (Mohna). For some, such as Mohna, it was the way teachers used worksheets that made the difference: “worksheets should be created and utilized as formative evaluations and also for encouraging hands-on, minds-on learning not just as copied text-based list of problems.”

All participants reported using mathematics worksheets but they were also critical of them. Worksheets were described as “drill and kill exercises,” offering few opportunities to challenge students (Rambo), hindering creativity in favour of the teacher’s activities (Lizzie), “getting the answer at the expense of in-depth understanding” (Anton), or closed problems that didn’t provide teachers access to their students’ thinking (Serena). Some, such as Rambo, reported his experience that students sometimes preferred worksheets to other more challenging work that required creativity or critical engagement.

In order to better understand mathematics worksheets as a genre, participants were asked to imagine possibilities for other ways in which mathematics worksheets might be structured or used. Participants suggested playing with the form of the worksheet as well as the content. They identified a sheet with the single division problem:

$$\frac{(-1)^{998} + (-1)^{895} + (+1)^{1000}}{(-1)^{901}}$$

accompanied with prompts: “I think the answer is ....because ... and... therefore ....” as an example of pushing the boundaries of what counts as a mathematics worksheet. All participants agreed with Rambo and considered this sheet to be more of a handout than a worksheet because it contains one question and “it asks for an explanation... it’s asking students to think.” Participants also discussed possible worksheets that challenged the typical structure of worksheets as progressing from easy to more difficult questions. In addition, it was suggested that worksheets could be designed to engage students in working with others in order to challenge the individual nature of worksheet engagement. All participants acknowledged Rambo’s suggestion of challenging the idea of worksheets as consisting of multiple questions offered to students all at once by instead developing “one problem at a time worksheets.” Such a worksheet could allow teachers to differentiate the questions to individual student interests or needs.

## CONCLUSIONS

The results of this study suggest that mathematics worksheets can be considered a genre. Findings revealed that mathematics worksheets have typified regularities (Miller, 1984) that conform to a certain consensus and mediate interactions (Bawarshi & Reiff, 2010). Analysis of the form, content, graphic and linguist features of worksheets provided characteristics that help define worksheets as culturally recognizable forms. Comparing the typical mathematics worksheet with contrasting or marginal examples provided further clarification in terms of the nature and generic structure of the worksheet genre. For instance, our results indicate that worksheets central to the genre were composed of questions that emphasized the calculational and procedural aspects of mathematics and reinforced drill-type skill development by highlighting accuracy and speed. Marginal forms, on the other hand, included questions that involved mathematical reasoning, pattern recognition and critical

thinking. Results indicate that although teachers are familiar with worksheets as a genre they are also able to consider possibilities for bending the genre, that is, thinking of possibilities for worksheets that extend its features and use. Worksheets could be created that allow for one question at a time, include questions that are more open-ended or questions which require students to raise their own questions.

A genre analysis of worksheets has helped clarify the form of worksheets that can shape activities in the mathematics classrooms. Genre-bending provided opportunities to think about worksheets and their use in a different way, and therefore opened possibilities for improving the structure and use of mathematics worksheets.

This study revealed that worksheets emphasized the procedural aspects of mathematics but not conjecturing, relating, or testing activities. The language analysis revealed that the authoritative language of worksheets positions students outside the mathematics community. If worksheets are used to force students to learn in a specific way, and treat them as a cohort rather than individuals without addressing individual abilities, interests and needs, worksheets become hegemonic and homogenizing force. This study contributes to our understanding of mathematics worksheets and provides a strategy, genre analysis, to engage in a critical analysis of worksheets as a genre. This study is an example of how educators can come together to reconsider and re-invent their use of worksheets in mathematics teaching and learning. As mathematics worksheets are recognized internationally as playing a role in mathematics teaching and learning, it is important that we gain a better understanding of how they are conceptualized, how they are used, and how they might be re-imagined. This study adds to the beginning research in this area and contributes to the analysis of mathematics texts by focusing on one kind of text, the mathematics worksheet.

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